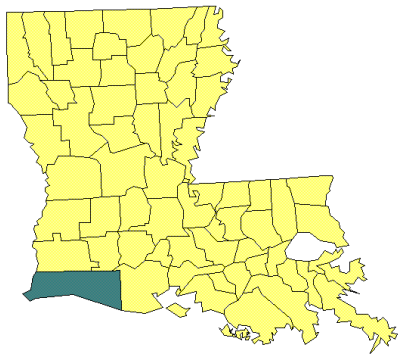
West Hackberry Tertiary Project -- Class I

Amoco Exploration and Production Co.



Hackberry Formation — West Hackberry Field

@ 8,000 ft. — Cameron Parish, Louisiana

Oligocene Age — Mississippi Salt Basin

DE-FC22-93BC14963

Contract Period:
9/3/1993 to 7/2/2002

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Objective: Amoco and the DOE are field testing the concept that air injection can be combined with the double displacement process (gas displacement of a water-invaded oil column to generate tertiary oil recovery through gravity drainage) to create a new EOR process for light oil reservoirs that would be profitable in today's economic environment. Although other gasses such as nitrogen or carbon dioxide can be combined with the double displacement process, air is lower cost and universally accessible even in remote or environmentally sensitive areas.

Technologies Used: Reservoir fluid and gas analysis, injectivity tests, production tests, reservoir modeling, directional drilling, open hole and closed hole logging.

Background: In fluvial-dominated deltaic reservoirs, miscible gas floods (involving CO2) are considered the strongest candidates for generating tertiary oil recovery. Few CO2 floods have been attempted in these reservoirs due to the poor accessibility and high cost of CO2. In steeply dipping West Hackberry oil reservoirs, gravity drainage recovers 80% - 90% of the OOIP while waterdrive recovers 50% - 60% of the original oil in place. By injecting air into a watered out or low pressure reservoir with a thin oil rim, a gas cap can be created or expanded to allow gravity drainage to occur thereby generating recoveries similar to miscible floods. Additionally, air injection combines excellent accessibility with low cost. The limiting factors to this process are the need for sufficient reservoir temperature for spontaneous combustion and sufficient bed dip for gravity drainage. Spontaneous combustion is required to prevent problems associated with oxygen breakthrough to producing wells.

Incremental Production: On the north flank of the field air injection has increased oil production by 120% above the decline in three low pressure reservoirs. As of November 1998 air injection has increased production by 300 BOPD with a total of 165,000 barrels of incremental oil production.

Expected Benefits and Applications: Over 3 million barrels of incremental oil recovery is expected from West Hackberry. Air injection is less costly than CO2 and can be applied in areas where CO2 is unavailable. It can be applied to many similar reservoirs throughout the Gulf Coast and other areas of the U.S. where deep reservoirs contain steeply dipping strata and high temperature environments. The double displacement process will be used to produce oil by gravity drainage. Air injection and in-situ combustion will repressurize the reservoir and create a front of combustion gases accelerating the gravity drainage process. The double displacement process will be used to produce oil by gravity drainage. Air injection and in-situ combustion will repressurize the reservoir and create a front of combustion gases accelerating the gravity drainage process.

Accomplishments: First economically viable EOR process which utilizes air injection in low pressure reservoirs. Evidence of in situ combustion and increased reservoir pressure in both high pressure and low pressure reservoirs by 1997-8. In July of 1997, air injection in the low pressure Cam C reservoir on the North Flank of the field was interrupted when the injection well became plugged with iron oxide. As of November 1998, air injection had increased oil production in the North Flank Cam C by 300 BOPD greater than the expected decline. By August 1998 over 165,000 barrels of incremental oil have been produced from the North Flank with an estimated 3 million barrels of incremental production expected from this project over the next twenty years. Air injection rates in the SL 42 No. 155 have averaged only 400 to 500 thousand standard cubic feet per day (MSCFD) due to iron oxide plugging the wellhead filter. To increase injection rates, facilities modifications are being implemented which are expected to relieve the plugging problem. One additional injector, the SL 42 No. 221, was added to the Cam C Reservoir during the fourth quarter of 1998 to increase injection rates and to provide a backup injector for the reservoir. Air injection began in the North Flank Cam D in December of 1997. The Cam D has one injector and two producers. The Cam D is by far the largest of the three low pressure North Flank reservoirs and thereby contains the most reserves. As of November 1998, air injection had increased production by 40 BOPD over the established decline. As a result of recent success in the low pressure reservoirs, two operators are looking at the process in their fields.

Publications: (1) During the last week of October 1997, an article discussing the West Hackberry Air Injection Project appeared in the Enhanced Energy Recovery News. (2) The November, 1997, issue of World Oil included an article entitled "A New/Economically Viable EOR Process for the U.S. Gulf Coast" which was co-authored by representatives from Amoco and LSU.

Recent/Upcoming Technology Transfer Events: (1) On October 6, 1997, "Keys to Increasing Production Via Air Injection in Gulf Coast Light Oil Reservoirs", T. Sullivan, SPE Annual Technical Conference and Exhibition in San Antonio, Texas. (2) On October 17, 1997, "Air Injection Enhanced Oil Recovery and 3-D Seismic: Revitalizing an Aging South Louisiana Oil Field" at the Gulf Coast Association of Geological

Societies' (GCAGS) Annual Convention in New Orleans, Louisiana. (3) On October 30, 1997, Amoco personnel reviewed the West Hackberry project at a technology transfer event in Houston, Texas, for the Texas Railroad Commission. (4) On January 23, 1998, a talk entitled "Air Injection: Low Cost IOR for Gulf Coast Reservoirs" was given at a technology transfer conference in New Orleans sponsored by LSU's Basin Research Institute. (5) On February 10, 1998, a West Hackberry talk was presented to the monthly meeting of the Mississippi Geological Society in Jackson, Mississippi. (6) T. Gillham, "Low Cost IOR: An Update on the West Hackberry Air Injection Project", SPE/DOE Eleventh Symposium on Improved Oil Recovery was held on April 19-22, 1998, in Tulsa, Oklahoma. (7) A talk on the West Hackberry project was presented to the Society of Professional Earth Scientists on January 21, 1999, in Houston, TX. (8) Gillham, T., "Air injection in a Gulf Coast light oil field", DOE Oil & Gas Conference", June 28-30, 1999, Dallas, TX.

Project Status: Project terminated at end of Budget Period I June 1999. Final report in press.